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A Research Note

EFFECT OF FRANKFURTER CURE INGREDIENTS ON N-NITROSODIMETHYLAMINE FORMATION IN A MODEL SYSTEM

INTRODUCTION

OUR LABORATORY has recently confirmed the presence of dimethylnitrosamine (DMNA) in a small number of samples of commercial frankfurters (Wasserman et al., 1972). In view of the carcinogenic nature of most N-nitrosamines, this finding could be of significance from a public health standpoint. However, the random manner in which positive samples appeared made it impossible to relate DMNA formation to residual concentration of sodium nitrite in the frankfurters. Frankfurters containing measurable concentrations of DMNA can be prepared in the pilot plant when approximately ten times the legally-permissible level of sodium nitrite is used (Fiddler et al., 1972a). Inhibition or reduction of DMNA formation was demonstrated in the presence of sodium ascorbate (Fiddler et al., 1972b) which is commonly used as an accelerator for the development of the characteristic cure color. The effect of the cure components on DMNA formation in frankfurters is being investigated. We feel that valuable information can be obtained through the use of model systems because the isolation, determination and confirmation of nitrosamines in meat products are complex and time-consuming procedures. This paper reports the effect of cure ingredients on DMNA formation under conditions approximating those used in the processing of frankfurters.

EXPERIMENTAL

THE CURE INGREDIENTS were purchased from commercial suppliers and were of food grade purity or better. Samples of each ingredient used in this study were obtained from at least two sources. With the exception of NaCl, which was used at 2.5% concentration, the other cure ingredients were tested at the maximum levels permitted in comminuted meat products, based on the weight of meat (85% of the emulsion weight). In the model system the following concentrations of cure ingredients were added as desired to 25 ml of pH 5.6 buffer solution (0.5M KH_2PO_4 and NaOH) in which 0.444 mM dimethylamine hydrochloride had been dissolved: sodium nitrite ($NaNO_2$) (3.3 mg, 156 ppm); sodium nitrate ($NaNO_3$) (36.1 mg, 1720 ppm); glucono-Δ-lactone (GDL), sodium acid pyrophosphate (SAPP), sodium tripolyphosphate (STPP) (106.3 mg, 5000 ppm); ascorbic acid (AscH) (10.0 mg, 468 ppm) and sodium ascorbate (NaAsc), sodium erythorbate (NaEry) (11.6 mg, 547 ppm). Sodium nitrite was always added after the other cure components. The reaction mixture, in a 100 ml round-bottom flask equipped with a condenser and magnetic stirring bar, was heated and stirred for 2 hr at 71°C (160°F). After cooling, the mixture was extracted three times with 30 ml CH_2Cl_2, then the combined extracts were concentrated to 1 ml using a Kuderna-Danish concentrator. The amount of DMNA formed was determined by GLC and the identity confirmed by mass spectrometry. The details of the analytical procedures have been reported previously (Fiddler et al., 1972a).

RESULTS & DISCUSSION

THE FORMATION of DMNA resulting from the reaction of frankfurter cure ingredients with dimethylamine is shown in Table 1.

Sodium nitrite, alone or in combination with NaCl or $NaNO_3$, yielded approximately the same amount of DMNA [60 μg/liter (ppb)] indicating the latter salts had no effect on DMNA formation. Glucono-Δ-lactone (GDL) and SAPP are recommended for use as cure color accelerators. Sodium acid pyrophosphate was only recently approved for use in comminuted meat products (Federal Register, 1972). When used with $NaNO_2$, SAPP had no effect on the formation of DMNA; GDL, however, led to the production of almost twice as much of the nitrosamine. The action of GDL may be due to the fact that this compound reduced the pH of the buffer solution to pH 5.45–5.50 whereas SAPP had no effect. In equimolar concentrations, GDL is a stronger acid than SAPP, thus tending to favor formation of DMNA which has an optimum pH of formation of 3.4 (Mirvish, 1970). In some preliminary studies with frankfurters prepared with 1500 ppm $NaNO_2$, we have also noted an increase in DMNA present with the use of GDL (Fiddler et al., 1972c). A recent publication by van Logten et al. (1972) which appeared during the preparation of this paper reports that canned meat cured with large amounts of $NaNO_2$ had higher concentrations of nitrosamines when GDL was present compared to $NaNO_2$ alone. These authors, however, attached no significance to this observation.

Phosphates, particularly sodium tripolyphosphate (STPP), are used in many meat preparations to increase water retention, thereby decreasing loss due to shrinkage during processing. Although

Table 1—Effect of sodium ascorbate and sodium erythorbate on the formation of DMNA in model systems containing dimethylamine, $NaNO_2$ and other cure components

Cure component[b]	DMNA formed, μg/liter (ppb)[a]		
	No reductant added	NaAsc added	NaEry added
None	63	39	28
NaCl	59	35	27
$NaNO_3$	59	32	37
GDL	117	32	33
SAPP	58	28	27
STPP	43	27	25
AscH	38	—[c]	—[c]
$NaNO_3$ + GDL	101	28	31
NaCl + STPP	49	31	30
NaCl + SAPP + STPP	55	30	31

[a] Confirmed by mass spectrometry
[b] Concentrations used are described in Experimental
[c] Not studied

STPP is presently not permitted in frankfurters, it could enter this product when trimmings of meat products containing STPP are used in the formulation. STPP alone was found to inhibit DMNA formation to some extent in our model system.

The reductant NaAsc markedly inhibits the formation of DMNA. Similar results have been obtained with frankfurters prepared with a high concentration of $NaNO_2$ and the reductant (Fiddler et al., 1972b). Free ascorbic acid (AscH) has about the same inhibitory activity as the sodium salt. Sodium erythorbate (NaEry) or isoascorbate, is used more commonly by meat processors. In the model system when used alone with $NaNO_2$, NaEry appeared to have a somewhat greater inhibitory effect on DMNA formation than NaAsc. However, in frankfurter preparations the activity of both reductants was the same (Fiddler et al., 1972c). Combinations of the other cure ingredients with either NaAsc or NaEry resulted in similar levels of inhibition of DMNA formation. It is interesting to note that the enhancing effect of DMNA formation by GDL alone is nullified in the presence of the reductants. The mechanisms of these reactions in the model systems and comminuted meats are under investigation.

To date there has been a good correlation between our frankfurter study and the model system which does not contain meat or meat byproducts. However, it is still not known at this time whether the results obtained from this model system study are applicable to comminuted meats.

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